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then, expanding, and removing the term involving x^3 (by the proper linear transformation) the coefficient of x also vanishes, and from this property we find that the relation between the coefficients of (9) is :

$$p^3 - 4pq + 8r = 0,$$

and in (10), the sum of two of the roots is equal to the sum of the other two.

(Cf. Burnside and Panton's *Theory of Equations*, page 41).

2nd Case. Assume that (9) can be put in the form

$$(mx + \frac{n}{x})^2 + g(mx + \frac{n}{x}) + f = 0 \dots (11).$$

Multiplying out, and comparing with (9), we find that the relation between the coefficients is $r^2 = p^2s$, and the roots of (11) are in geometrical progression.

Also solved by CHARLES C. CROSS, B. L. REMICK, J. SCHEFFER, H. C. WHITAKER, and J. W. YOUNG.

116. Proposed by ARTEMAS MARTIN, A. M., Ph. D., LL. D., U. S. Coast and Geodetic Survey Office, Washington, D. C.

Solve the equations :

$$w(xy + yz + xz) = a ; x(wy + wz + yz) = b ;$$

$$y(wx + wz + xz) = c ; z(wx + wy + xy) = d.$$

I. Solution by G. B. M. ZEZE, A. M., Ph. D., The Temple College, Philadelphia, Pa.; J. M. HOWIE, The Nebraska State Normal School, Peru, Neb.; B. L. REMICK, Bradley Polytechnic Institute, Peoria, Ill.; NOAH ADAIR, A. M., Tyler College, Tyler, Tex.; G. I. HOPKINS, High School, Manchester, N.H.; FREMONT CRANE, B. S., C. E., Stockett, Mont.; H. C. WHITAKER, Ph.D., Manual Training School, Philadelphia, Pa., C. C. CROSS, Meredithville, Va.; L. B. FILLMAN, Chester, Pa.; O. S. WESTCOTT, A. M., Sc. D., North Division High School, Chicago, Ill.; and W. W. LANDIS, A. M., Dickinson College, Carlisle, Pa.

$$(1) + (2) + (3) + (4) \text{ gives } wxy + wxz + wyz + xyz = \frac{1}{3}(a + b + c + d) \dots (5).$$

$$(5) - (1) \text{ gives } xyz = \frac{1}{3}(b + c + d - 2a) \dots (6).$$

$$(5) - (2) \text{ gives } wyz = \frac{1}{3}(a + c + d - 2b) \dots (7).$$

$$(5) - (3) \text{ gives } wxz = \frac{1}{3}(a + b + d - 2c) \dots (8).$$

$$(5) - (4) \text{ gives } wxy = \frac{1}{3}(a + b + c - 2d) \dots (9).$$

$$(6) \div (7) \text{ gives } x/w = (b + c + d - 2a)/(a + c + d - 2b).$$

$$(6) \div (8) \text{ gives } y/w = (b + c + d - 2a)/(a + b + d - 2c).$$

$$(6) \div (9) \text{ gives } z/w = (b + c + d - 2a)/(a + b + c - 2d).$$

These values of x , y , and z in (1) give

$$w = \sqrt[3]{\frac{(a+b+c-2d)(a+b+d-2c)(a+c+d-2b)}{3(b+c+d-2a)^2}} = \sqrt[3]{\frac{BCD}{3A^2}}, \text{ suppose.}$$

$$\text{Similarly, } x = \sqrt[3]{(ACD/3B^2)}, y = \sqrt[3]{(ABD/3C^2)}, z = \sqrt[3]{(ABC/3D^2)}.$$

II. Solution by J. SCHEFFER, A. M., Hagerstown, Md.; M. A. GRUBER, A. M., War Department, Washington, D. C.; J. H. DRUMMOND, LL. D., Portland, Me.; ELMER SCHUYLER, B. Sc., Boys' High School, Reading, Pa.; COOPER D. SCHMITT, M. A., University of Tennessee, Knoxville, Tenn.; and H. S. VANDIVER, Bala, Pa.

Putting $xyzw=P$, the given equations change into the following :

$$P/z + P/y + P/x = a, \quad P/z + P/y + P/w = b,$$

$$P/z + P/x + P/w = c, \quad P/y + P/x + P/w = d.$$

Adding, we get $P/x + P/y + P/z + P/w = \frac{a+b+c+d}{3}$.

Putting $\frac{a+b+c+d}{3} = s$, and subtracting each of the above equations, gives

$$P/w = s - a, \quad P/x = s - b, \quad P/y = s - c, \quad P/z = s - d.$$

Multiplying, $P^3 = (s-a)(s-b)(s-c)(s-d)$.

$$\therefore x = \sqrt[3]{\frac{(s-a)(s-c)(s-d)}{(s-b)^2}}, \quad y = \sqrt[3]{\frac{(s-a)(s-b)(s-d)}{(s-c)^2}},$$

$$z = \sqrt[3]{\frac{(s-a)(s-b)(s-c)}{(s-d)^2}}, \quad w = \sqrt[3]{\frac{(s-b)(s-c)(s-d)}{(s-a)^2}}.$$

GEOMETRY.

146. Proposed by H. R. HIGLEY, M. Sc., Professor of Mathematics, Normal School, East Stroudsburg, Pa.

If the opposite sides of a quadrilateral inscribed in a circle be produced to meet, the square on the line joining the points of concurrence = the sum of the squares on the two tangents from these points. Ex. 24, page 219, Mackay's *Elements of Euclid*.

Solution by G. B. M. ZERR, A. M., Ph. D., The Temple College, Philadelphia, Pa., and J. SCHEFFER, A. M., Hagerstown, Md.

Let $ABCD$ be the inscribed quadrilateral ; E, F the intersection of the opposite sides produced ; O the center of the circle ; M the intersection of the diagonals ; EG tangent from E ; FH, FL tangents from F .

Draw EF , EM and let EM cut FO in K . It has been shown that EM is the polar of F .

$\therefore EM$ passes through L, H and is perpendicular to OF .

$$\therefore EF^2 = FK^2 + FK^2.$$

$$\text{But } EK^2 = EO^2 - OK^2, \quad FK^2 = (FO - OK)^2.$$

$$\therefore FK^2 = FO^2 - 2FO \cdot OK + OK^2.$$

$$\text{But } 2FO \cdot OK = 2OH^2 = 2r^2. \quad \therefore EK^2 + FK^2 = EO^2 + FO^2 - 2r^2.$$

$$EG^2 = EO^2 - r^2, \quad FH^2 = FO^2 - r^2.$$

$$\therefore EG^2 + FH^2 = EO^2 + FO^2 - 2r^2 = EK^2 + FK^2 = EF^2.$$

